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(57) **ABSTRACT**

The frequency standard comprises a quantum absorber, source of incident electro-magnetic radiation, detector, controller and signal output. The quantum absorber has a transition between a lower quantum state split by hyperfine interaction into two lower sub-state groups of at least one lower sub-state, and an upper quantum split by hyperfine interaction into upper sub-state groups of at least one upper sub-state. None of the upper sub-state groups is a cycling transition sub-state group having at least one allowed electric dipole transition to one lower sub-state group but none to the other. The upper quantum state differs in energy from a first lower sub-state in one of the lower sub-state groups and from a second lower sub-state in the other of the lower sub-state groups by energy differences that correspond to frequencies of ω_1 and ω_2 , respectively. The source is arranged to irradiate the quantum absorber with the incident electro-magnetic radiation that includes two main frequency components having frequencies equal to ω_1 and ω_2 . The detector generates a detection signal in response to electro-magnetic radiation from the quantum absorber. The controller is responsive to the detection signal and controls the source to generate the main frequency components with a frequency difference that obtains an extremum in the detection signal. The extremum indicates that the frequency difference corresponds to an energy difference between the first and second lower sub-states. The signal output provides a frequency standard signal related in frequency to the frequency difference.

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(56) **References Cited**

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20 Claims, 5 Drawing Sheets

